Current Science International, 3(1): 26-33, 2014
ISSN: 2077-4435

Effect of Replacement of Wheat Flour with Mushroom Powder and Sweet Potato Flour on Nutritional Composition and Sensory Characteristics of Biscuits

M.I. Ibrahium and A.I. Hegazy

Food Science and Technology Department, Faculty of Agriculture, Cairo, AL-Azhar University, Egypt.

ABSTRACT

This research was performed to evaluate the effect of partial replacement of wheat flour by different levels (10, 20 and 30%) of the mixture of mushroom powder (MP) and sweet potato flour (SPF) at equal rates (1:1 w:w) on the chemical and sensory characteristics for produced biscuits. Also, the produced biscuits batches were evaluated for their amino acids composition and compared with control biscuit (100% wheat flour). The present results of chemical analyses indicated that the incorporation of MP/SPF into biscuits formula led to increase the contents of protein, fiber, ash, Fe, Ca, K, P and indispensable amino acids (IAA_s) with increasing the incorporation level of MP/SPF mixture. The amino acids composition revealed that MP/SPF-biscuits contained most of IAA_s at higher concentrations than the reference protein pattern of FAO/WHO, with exception of lysine and sulfur amino acids. Lysine was the first limiting amino acid in wheat biscuit (37%) and its chemical score reached 81% after supplementation with 30% MP/SPF mixture. Also, the present results revealed that biscuits processed from wheat flour supplemented by 10% or 20% of MP/SPF mixture exhibited a good sensory properties and better acceptability. While, the produced biscuit batch was contain 30% MP/SPF significantly varied ($P<0.05$) and had less judging scores for the tested organoleptic quality properties and less acceptability as compared with the other samples. Therefore, it could be concluded that the incorporation of 20% MP/SPF into wheat biscuit formula considerably improved the nutritional and sensory quality properties of produced biscuit batches.

Key words: Biscuit, Mushroom, Sweet potato, Chemical composition, Nutritional protein quality, Sensory properties.

Introduction

Biscuits are considered one of the convenient food products which consume from all segments of society in Egypt. The reasons of wide popularity are low cost, good nutritional quality and availability in different varieties, varied taste, easy availability and longer shelf-life (Gandhi *et al.*, 2001; Hooda and Jood, 2005; and Sudha *et al.*, 2007). Several studies indicated that the nutritional, physical and sensory characteristic of biscuits depend on both the physicochemical properties of the flour and processing method employed for flour preparation (Wan-Rosli *et al.*, 2012). The enrichment of protein biscuits may be achieved through the incorporation of rich protein sources (Gandhi *et al.*, 2001 and Sharma and Chauhan, 2002). Mushroom of one these sources, which have a great potential, due to their high and good quality-protein (Varughese *et al.*, 1996; Petrovska *et al.*, 2002; Adebayo-Oyetoro *et al.*, 2010; Al-Enazi *et al.*, 2012; Wan-Rosli *et al.*, 2012 and Adebayo *et al.*, 2014).

More than 2000 species of mushrooms exist in nature; however, less than 25 species are widely accepted as an important food (Lindequist *et al.*, 2005 and Lillian *et al.*, 2007) for their nutritional (Breene, 1990; Manzi *et al.*, 1999 and Al-Enazi *et al.*, 2012), organoleptic (Maga, 1981 and Mattila *et al.*, 2000) and pharmacological (Bobek *et al.*,1995; Bobek and Galbavy, 1999 and Lindequist *et al.*, 2005) characteristics. Historically, mushrooms have been used for both medicinal and culinary properties in many parts of the world. It is associated with many pharmacological properties by both eastern and western medicine. These functions include reducing cholesterol (Bobek *et al.*, 1991 and Bobek *et al.*, 1997), lowering blood pressure, strengthening the immune system against diseases (Reguła and Siwulski, 2007), combating tumors (Mau *et al.*, 2004), improving liver function (Wang *et al.*, 2000) and inhibits hypertensive effects through its active ingredients, which affect the renin-angiotensin system (Chang and Miles, 1989; Chang, 1996 and Bobek and Galbavy, 1999).

Mushrooms are rich sources of nutraceuticals (Elmastas *et al.*, 2007 and Ribeiro *et al.*, 2007) that are responsible for their antioxidant (Adebayo *et al.*, 2014), antitumor (Wasser and Weis, 1999) and antimicrobial properties (Lindequist *et al.*, 2005; Barros *et al.*, 2007*a* and Turkoglu *et al.*, 2007). Medicinal mushroom extracts were considered as important remedies for the prevention of many diseases for thousands of years especially in the Oriental regions (Wasser and Weis, 1999 and Israilides and Philippoussis, 2003) such as diabetic, cancer, heart diseases (Bobek and Galbavy, 1999), atherosclerosis and cirrhosis (Ishikawa *et al.*, 2001).

Corresponding Author: M.I. Ibrahium, Food Science and Technology Department, Faculty of Agriculture, Cairo, AL-Azhar University, Egypt.

Curr. Sci. Int., 3(1): 26-33, 2014

Besides their pharmacological features, the consumption of edible mushrooms is increased due to their nutritional value, related to high protein (30 to 40% on dry weight basis), vitamins and minerals (Yaovadee *et al.,* 2010 and Adebayo *et al.* 2014), low fat contents (Diez and Alvarez, 2001 and Barros *et al.,* 2007*b*), and are preferred due to their special flavor and aroma (Yaovadee *et al.,* 2010). In addition to their role as protein monomeric units, R-amino acids are being as energy metabolites and precursors of many biologically important nitrogen-containing compounds such as heme, glutathione, various hormones, nucleotides, nucleotide coenzymes, physiologically active amines (Rbara *et al.,* 2008 and Teng *et al.,* 2014), and alkaloids (Kobori *et al.,* 2007).

Sweet potato is utilized in a lot of uses in the household feeding and food industries. It is considered as a resource of functional foods because of its high contents of physiologically active compounds such as vitamins A, C, E, thiamin, riboflavin and niacin (Misra and Kulshrestha, 2003; Ishiguro *et al.,* 2004; Guang and Wu, 2006 and Vasantharuba *et al.,* 2012), as well as it contains a good amount of minerals and essential amino acids (Broihier, 2006 and Padmaja, 2009), and therefore it can be substituted for wheat flour in the preparation of various bakery products. This helps in increase the nutritive value of product with lowering the gluten level, consequently prevent Celiac disease in people who suffer from allergies to gluten (Tilman *et al.,* 2003; Hill *et al.,* 2005 and Singh *et al.,* 2008). In addition to, the potato flour enhances the sensory characteristics by adding natural sweetness, color, flavor and dietary fiber to processed food products (Yadav *et al.,* 2006).

Several studies reported that sweet potato flour is an excellent source of phytochemical constituents containing anthocyanin and phenolic acids (such as caffeic, chlorogenic, monocaffeoylquinic, dicaffeoylquinic and tricaffeoylquinic acids) and is superior to other vegetables (Ishiguro *et al.,* 2004; Padda and Picha, 2008 and Padmaja, 2009). These biologically active compounds possess multifaceted action including antioxidation (Liu *et al.,* 2014), antibacterial, antimutagenicity, anti-inflammation (Bovelle-Benjamin, 2007), anti-diabetes and anticarcinogenesis (Antonio *et al.,* 2011 and Gustafson *et al.,* 2012).

Information on incorporation of mushroom powder or sweet potato flour in bakery products is scanty. Thus, this study was designed to evaluate the suitability of replacement wheat flour by 10, 20 and 30% of mushroom powder and sweet potato flour (MP/SPF) mixture at equal rates (1:1 w:w) on the chemical and sensory characteristics of produced biscuit batches. Also, nutritional protein quality of final products was evaluated according to their content of indispensable amino acids (IAAs) in comparison to the reference protein pattern of FAO/WHO (1989).

Materials and Methods

Materials:

Edible mushroom (*Pleurotus plumonarius*) was obtained from Agriculture Research Center, Giza, Egypt. Fresh sweet potato (*Ipomoea batatas*), Wheat flour (72% extraction) and other ingredients were obtained from the local markets in Cairo city. Ingredients used in processing of biscuits included 65.1% wheat flour or blends, 21.4% sugar, 9.3% shortening (palm oil), 0.93% skimmed milk powder, 1.86% high fructose, 0.37% sodium bicarbonate, 1.02% ammonium bicarbonate, 0.02% vanilla and the required amount of water.

Methods:

Preparation of Sweet Potato Flour (SPF):

Fresh sweet potato without infection or infestation was thoroughly washed in running tap water to remove any adhering soil, dirt and dust. Afterward, the tubers were peeled, washed, blanched with 0.25% of sodium metabisulphite solution for 15mins, cut into thin slices and dried in a Gallenkamp hotbox oven at 55±5 °C for 18 hrs. The dried sweet potato chips were milled into flour (Eke-Ejiofor and Kiin-Kabari, 2010 and Vasantharuba *et al.,* 2012). After complete drying, the slices were milled, passed through 80 mesh sieve to obtain fine flour of uniform size. Flour obtained was sieved through a 60mm mesh sieve to obtain flour of uniform particle size. The prepared sweet potato flour was packed in airtight plastic packages until further use.

Processing of Biscuits:

Fat and sucrose were firstly creamed by using the mechanical mixer for 10 min. Sodium bicarbonate and ammonium bicarbonate were dissolved in a part of water and added to the prepared creamed mixture, then high fructose was added. As creaming process was continued, wheat flour or blends, skimmed milk powder and vanilla were added and stirred well together. The full prepared dough was laminated, sheeted, extruded, molded and formed to the required form. The formed biscuits were baked at 230°C for 7 min. according to the AACC (1995). After cooling for 30 min, biscuits were packed in cellophane packages until further analysis.

Curr. Sci. Int., 3(1): 26-33, 2014

Preparation of Mushroom Powder (MP):

The mushrooms were washed by clean water blanched with steam for 7 min and dried in a thermostatically controlled oven with air fan to 55±5 °C for 120 min. The dried mushroom was ground into powder form to pass through a 20 mesh/inch sieve, until using (Deshpande and Tamhne, 1981 and Paeaekkoenen and Kurbela, 1987).

Preparation of Mushroom Powder/Sweet Potato Flour (MP/SPF) Mixtures:

Wheat flour was supplemented by 10, 20 and 30% of MP and SPF mixture (at ratio 1:1 w/w). The composition of produced blends is showed in Table (1).

Table 1: Formation of wheat flour and MP/SPF mixture blends used in biscuit batches production:

Treatments	Ingredients (%)		
	Wheat flour	MP	SPF
Control	100	-	-
Blend 1	90	5	5
Blend 2	80	10	10
Blend 3	70	15	15

Chemical Analysis:

Proximate analysis of the biscuit samples was determined using the standard methods of the AOAC (2000). Iron, calcium, potassium and phosphorus contents were determined by atomic absorption (Perkin-Elmer-Crop, Norwalk, model 560) according to the standard methods of the AOAC (2000). Amino acids composition of the tested samples was determined using HPLC-Pico-Tag method as described in the AOAC (2005). Where, the indispensable amino acid (IAA) chemical score (A.S) = IAA content (g/100 g) of tested protein x 100 / IAA content (g/100 g) of reference protein pattern of FAO/WHO (1989).The IAA had the lowest score would be considered as the first limiting amino acid and subsequently the second limiting amino acids. Chemical analysis results represented the mean of the obtained result for tested parameter in triplicate samples.

Sensory Evaluation for Produced Biscuits Batches:

The sensory evaluation of biscuits containing MP/SPF mixture at different levels and control (wheat biscuit) was performed by 10 panelists from the staff members of Food Science and Technology Department, Faculty of Agriculture, Cairo, AL-Azhar University). The panelists were asked to evaluate color, appearance, taste, flavor, texture and overall acceptability. During the panel test, rinse the panelist's mouth by water to remove any traces of residual food. The ratings were on a 9-point hedonic scale, ranging from 9 as like extremely to 1 as dislike extremely as outlined by Ihekoronye and Ngoddy (1985).

Statistical Analysis:

The obtained data of sensory evaluation of produced biscuit batches were statistically analyzed by using SPSS (Version 16.0 software Inc., Chicago, USA) of completely randomized design as described by Gomez and Gomez (1984). Treatment means were compared using the least significant differences (LSD) at 0.05 of probability level.

Results and Discussion

1. Nutritional Protein Quality of Mushroom Powder and Sweet Potato Flour:

The nutritional quality of mushroom powder (MP) and sweet potato flour (SPF) proteins was evaluated according to their contents of the indispensable amino acids (IAA_s) and comparison with soy protein concentrate (SPC) and the reference protein pattern of FAO/WHO (1989) as shown in Table (2).

From the obtained results (Table 2), it could be observed that mushroom powder contained most of IAA_s at higher concentrations than the corresponding concentrations of those in reference protein pattern of FAO/WHO, with exception of amino acids containing sulphur (methionine and cysteine). Since, the chemical score for the former two amino acids together was lower than 100. This result is in approximately similar with the previous studies results of Bernas *et al.,* (2006); Rbara *et al.,* (2008) and Al-Enazi *et al.,* (2012) who reported that the most limiting amino acids in the mushroom were amino acids containing sulphur, but the rest of the amino acids were at very satisfactory levels. While, Yaovadee *et al.,* (2010) demonstrated that the tryptophan was the limiting amino acid in all tested mushroom samples.

Curr. Sci. Int., 3(1): 26-33, 2014

Table 2: Amino acids composition of mushroom powder (MP) and sweet potato flour (SPF) compared to soy protein concentrate (SPC) and reference protein pattern of FAO/WHO:

Amino acids	MP		SPF		SPC		FAO/WHO
	g/16g N	A.S*	g/16g N	A.S*	g/16g N	A.S*	
Isoleucine	4.8	120	3.8	95	4.8	120	4.0
Leucine	7.3	104	6.6	94	7.6	109	7.0
Lysine	7.6	138	4.7	85	6.1	111	5.5
Valine	6.3	126	5.1	102	6.2	124	5.0
Therionine	4.2	105	4.4	110	3.9	98	4.0
Meth+Cyst	1.9	56	2.1	62	2.4	71	3.4
Phen+Tyro	7.8	128	9.6	157	8.3	136	6.1
Tryptophan	1.6	160	0.8	80	1.2	120	1.0

**A.S: Chemical score of indispensable amino acid; Meth & Cyst: Methionine & Cysteine; Phen & Tyro: Phenylalanine & Tyrosine*

The comparison between IAA_s composition of sweet potato flour (SPF) and soy protein concentrate (SPC), as given in Table (2), SPF protein contained a lower contents of all indispensable amino acids (IAA_s) than those of the corresponding IAA_s in the SPC, with the exception of therionine and aromatic amino acids (phenylalinine and tyrosine) which were found at a higher content in the SPF protein. On the other hand, the SPF protein was deficient in isoleucine, leucine, lysine, tryptophan and amino acids containing sulpher, and contained a high level of valine, therionine and aromatic amino acids (phenylalinine and tyrosine); when compared with the reference protein pattern of FAO/WHO (1989). The first limiting IAA of the SPF protein was amino acid containing sulpher and the second limiting IAA was tryptophan. These results are in conformity with those reported by Walter *et al.* (1984) and Bradbury and Holloway (1988).

2. Chemical Composition of Biscuits Containing MP/SPF Mixture:

The chemical composition results for biscuits made from wheat flour and its blends with 10, 20 and 30% MP/SPF mixture were tabulated as in Table (3).

As shown in Table (3), the contents of protein, fat, crude fiber and ash were gradually increased with increasing the incorporation level of MP/SPF mixture as compared with control biscuit. This alteration could be attributed to the addition of mushroom (Suzuki and Oshima, 1996; Al-Enazi *et al.*, 2012 and Adebayo *et al.*, 2014) and sweet potato (Khaliduzzaman *et al.*, 2010; Vasantharuba *et al.*, 2012 and Eke-Ejiofor, 2013**)** flours as partial substituting of wheat flour in making biscuit; which are rich in protein content and the other components. In this regard, Adebayo-Oyetoro *et al.*, (2010) and Jauharah *et al.*, (2014) indicated that the supplementing wheat flour with mushroom powder would greatly improve the protein nutritional quality of cookies. On the other hand, a slight decrease in total carbohydrates content was noticed in the same samples and reached 64.30% in biscuit batch containing 30% MP/SPF mixture, against 67.21% of control sample. These findings are in agreement with the results of Fayemi (1999) and Adebayo-Oyetoro *et al.*, (2010) who indicated that the carbohydrates content decreased with the increasing the incorporation level of the mushroom flour added to wheat flour used for making cookies.

Table 3: Chemical composition (on dry weight basis) and some minerals content of biscuits supplemented by MP/SPF at different levels:

Substitution level (%)	Gross chemical component (%)					Minerals content (mg/100g)			
	Protein	Fat	Fiber	Ash	Carbohydrates	Fe	Ca	K	P
Control	8.74	21.02	1.60	1.43	67.21	4.56	34.54	7.18	8.24
W : MP/SPF									
90 : 10	8.91	21.64	1.68	1.56	66.21	6.01	38.26	16.45	10.02
80 : 20	9.20	22.15	1.74	1.69	65.22	7.64	43.17	27.78	12.10
70 : 30	9.46	22.57	1.87	1.80	64.30	8.78	49.08	41.23	15.34

From the obtained results (Table 3), it could be also observed that the control biscuit made from wheat flour contained Fe, Ca, K and P at level of 4.56, 34.54, 7.18 and 8.24 mg/100g, on dry weight basis; respectively. In addition that produced biscuit batches contents from the former minerals were increased with increasing the incorporation level of MP/SPF mixture into the biscuit formula. Where, biscuit containing 30% MP/SPF mixture exhibited higher contents of Fe (8.78), Ca (49.08), K (41.23) and P (15.34 mg/100g) than other biscuit batches. This attributing to the high contents of mineral salts in mushroom (Caglarirmak, 2007 and Adebayo *et al.*, 2014) and sweet potato (Grabowski *et al.*, 2008 and Padmaja, 2009); when compared with wheat flour.

3. Nutritional Protein Quality of Biscuits Supplemented by MP/SPF Mixture:

The nutritional quality of produced biscuit batches supplemented with MP/SPF mixture at different levels (0, 10, 20 and 30%) was evaluated according to their contents of the indispensable amino acids (IAA_s) in comparison to the reference protein pattern of FAO/WHO (1989) as evident in Table (4).

Curr. Sci. Int., 3(1): 26-33, 2014

Table 4: Amino acids content of biscuits supplemented by MP/SPF at different levels:

Amino acids	Control (wheat flour)		Substitution level						FAO/WHO
			10%		20%		30%		
	g/100g	A.S*	g/100g	A.S	g/100g	A.S	g/100g	A.S	
Isoleucine	2.53	90	2.89	103	3.17	113	3.48	124	2.80
Leucine	5.57	84	6.14	93	6.79	103	7.11	108	6.61
Lysine	2.13	37	3.24	56	4.08	70	4.72	81	5.80
Valine	2.92	83	3.30	94	3.72	106	4.00	114	3.50
Therionine	2.03	85	2.48	103	2.86	119	3.02	126	2.40
Meth+Cyst	1.67	49	2.37	70	2.99	88	3.31	97	3.40
Phen+Tyro	6.48	103	7.12	113	7.80	124	7.95	126	6.30
Tryptophan	1.04	95	1.10	100	1.37	125	1.59	145	1.10
Aspartic	4.17	-	5.22	-	5.94	-	7.31	-	-
Glutamic	30.87	-	28.34	-	26.02	-	23.86	-	-
Alanine	3.02	-	3.16	-	3.31	-	3.76	-	-
Arginine	9.41	-	9.03	-	8.80	-	8.12	-	-
Serine	4.76	-	4.74	-	4.71	-	4.69	-	-
Proline	6.09	-	5.98	-	5.89	-	5.83	-	-
Glycine	1.97	-	2.06	-	2.21	-	2.50	-	-
Histidine	2.11	-	2.09	-	2.00	-	1.96	-	-

**A.S: Chemical score of indispensable amino acid; Meth & Cyst: Methionine & Cysteine; Phen & Tyro: Phenylalanine & Tyrosine.*

From Table (4), it could be observed that MP/SPF-biscuits at concentration 20 or 30% contained most of IAA_s at higher concentrations than reference protein pattern of FAO/WHO (chemical score higher than 100), with exception of lysine and sulfur amino acids (lower than 100). Also, lysine was the first limiting amino acid for the control biscuit (37%), when biscuits were supplemented by MP/SPF mixture, lysine score elevated and reached 81% in biscuit containing 30% MP/SPF mixture.

Also, incorporation of MP/SPF mixture into wheat flour blends resulted in the increase of some dispensable amino acids (DAA_s) content for biscuits produced as shown in Table (4). In this regard, Hegazy and Ibrahium (2009); Adebayo-Oyetoro *et al.* (2010) and Wan-Rosli *et al.* (2012) found that the wheat biscuit is considered nutritionally poor due to deficiency of most indispensable amino acids especially lysine and the fortification of wheat flour with non-wheat proteins at different ratios resulted in increase the protein quality through improving its amino acid profile.

Generally, mushroom and sweet potato complement well wheat flour to produce high nutritional quality biscuits due to their high contents of lysine, threonine, tyrosine, phenylalanine, leucine, isoleucine, valine, tryptophan, glycine, arginine and alanine (Yeoh and Truong, 1996; Petrovska, 2001 and Al-Enazi *et al.*, 2012).

4. Sensory Characteristics of Biscuits Containing MP/SPF Mixture:

Biscuits supplemented by different levels of MP/SPF mixture were sensory evaluated and compared with control biscuit (100% wheat flour) as shown in Table (5).

Table 5: Sensory characteristics* of biscuits supplemented by MP/SPF at different levels:

Substitution level (%)	Organoleptic properties					Overall acceptability
	Color	Appearance	Flavor	Taste	Texture	
Control	8.11^a	8.04^a	8.36^a	8.78^a	8.13^a	8.28^a
W : MP/SPF						
90 : 10	8.04^a	7.98^a	8.38^a	8.39^a	7.91^a	8.00^a
80 : 20	7.96^a	7.74^a	8.42^a	8.11^a	7.14^b	7.87^a
70 : 30	7.21^b	7.06^b	7.82^b	7.14^b	6.79^c	6.98^b

**Scores were: 9 = like extremely to 1 = dislike extremely*

^{a,b} and ^{c} means in the same column with different superscripts are different significantly ($p< 0.05$)

As shown in Table (5), there were no significant differences among control sample and biscuit samples containing 10% or 20% of MP/SPF mixture in all sensory characteristics with exception, the texture of 20% MP/SPF-sample was significantly reduced ($P<0.05$) when compared with control sample. But the biscuit sample containing 30% MP/SPF mixture was significantly different ($P<0.05$) in all properties and had less judging scores as compared to the other samples. Whereas overall acceptability score for these sample was 6.98, against 8.28 of control biscuit. It is worth to mention that the control sample has flavor score lower than the biscuit batches contained 10 and 20% MP/SPF mixture. Whereas flavor score increased from 8.36 to 8.42 with increase MP/SPF level in the biscuit formula. This may be due to the volatile flavor constituents in sweet potato flour which gives the good flavor characteristics as reported by Purcell *et al.*, (1980). In this concern, Nazni *et al.* (2009) reported that potato flour incorporated biscuits had the highest scores for overall acceptability when compared to maize and green gram flour incorporated biscuits.

Generally, substitution levels of up to 20% were acceptable in biscuit samples. The ingredients level and recipes of biscuit preparation may affect the sensory attributes, consumer's preference and overall acceptability (Nazni and Pradeepa, 2010 and Eke-Ejiofor, 2013).

In conclusion, the results of this study indicate that it is possible and may be desirable to partially substitute wheat flour with mushroom powder and sweet potato flour for the purposes of biscuits production. Flour substitution up to 20% MP/SPF mixture into wheat biscuit formula resulted in improving their chemical and nutritional quality characteristics and was acceptable to the panelists. In addition, it also complemented the deficiency in leucine, isoleucine, lysine, threonine, valine and tryptophan, hence neutralized the imbalance amino acids profile.

References

AACC, 1995. American Association of Cereal Chemistry. Approved methods of the American Beverage and Food World. Association of Cereal Chemists. 10 ed. Method 44- 18. pp: 31-34

Adebayo, E.A., J.K. Oloke, D.A. Aina and T.C. Bora, 2014. Antioxdant and nutritional importance of some pleurotus species. J. Micro. Biotech. Food Sci. 3: 289-294.

Adebayo-Oyetoro, A.O., O.P. Olatidoye, O.O. Ogundipe, I.O. Balogun and F.O. Aro, 2010. Quality characteristics of cookies produced from composite flours of wheat and mushroom. J. Sci. and Multidisciplinary Res., pp: 25-31.

Al-Enazi, M.M., A.Z. El-Bahrawy and M.A. El-Khateeb, 2012. *In vivo* evaluation of the proteins in the cultivated mushrooms. J. Nutr. Food Sci. pp: 2-10.

Antonio, G.C., C.Y. Takeiti, R.A. Oliveira and K.J. Park, 2011. Sweet potato: Production, morphological and physiochemical characteristics and technological process. Global Science Books, (Special Issue 2): pp: 1-18.

AOAC, 2000. Official Methods of Analysis, 17th edition. Association of Official Analytical Chemists. Horowitz W. (ed.) Vols. 1 and 2, AOAC International, Maryland, USA.

AOAC, 2005. Official Methods of Analysis, 18th edition. Association of Official Analytical Chemists, Maryland, USA, pp: 1-32.

Barros, L., P. Baptista, D.M Correira, S. Casa, B. Oliveira and I.C. Ferreir, 2007*b*. Total phenols, beta-carotene and lycopene in Portuguese wild edible mushrooms and their antioxidant activities. Food Chem., 105: 413-419.

Barros, L., P. Baptista, D.M. Correira, S. Casa, B. Oliveira and I.C. Ferreir, 2007*a*. Fatty acid, sugar compositions and nutritional value of five wild edible mushrooms from Northeast Portugal. Food Chem., 105: 140-145.

Bernas, E., G. Jaworska and Z. Lisiewska, 2006. Edible mushrooms as a source of valuable nutritive constituents. Acta Sci. Pol. Technol. Aliment. 1: 5-20.

Bobek, P. and S. Galbavy, 1999. Hypercholesterolemic and anti-atherogenic effect of oyster mushroom *(Pleurotus ostreatus)* in rabbit. Nahrung, 45: 339-342.

Bobek, P., E. Ginter, M. Jurcovicova and K. Kunia, 1991. Cholesterol lowering effect of the mushroom *(Pleurotus ostreatus)* in hereditary hypercholesterolemic rats. Annals of Nutritional Metabolism, 35: 191-195.

Bobek, P., I. Ozdin and I. Kuniak, 1997. Effect of oyster mushroom and isolated P-glucan on lipid peroxidation and on the activities of antioxidative enzymes in rats fed the cholesterol diet. Nutritional Biochemistry, 8: 469-471.

Bobek, P., I. Ozdyn and I. Kuniak, 1995. The effect of oyster *(Pleurotus ostreatus)* its ethanolic extract and extraction residues on cholesterol levels in serumlipoproteins and liver of rat. Nahrung, 39: 98-99.

Bovelle-Benjamin, A.C., 2007. Sweet potato: A review of its past, present and Future role in human nutrition. Advances in Food and Nutrition Res., 52: 1-59.

Bradbury, J.H. and W.D. Holloway, 1988. Chemistry of Tropical Root Crops: Significance for Nutrition and Agriculture in the Pacific, pp: 39-56, 151-160.

Breene, W.M., 1990. Nutritional and medicinal value of specially mushrooms. J. Food Protection, 53: 883-894.

Broihier, K., 2006. Sweet potato: Tuber delivers top-notch nutrition. Environ. Nutr., 29: 8.

Caglarirmak, N., 2007. The nutrients of exotic mushrooms (*Lentinula edodes* and *Pleurotus* species) and an estimated approach to the volatile compounds. Food Chemistry, 105: 1188-1194.

Chang, R., 1996. Functional properties of edible mushroom. Nutrition Review, 54: 91-93.

Chang, S.T. and P.G. Miles, 1989. Biology and cultivation of edible mushrooms. Academic Press, London, 265-274.

Deshpande, A. and D. Tamhne, 1981. Studies on dehydration of mushrooms. J. Food Sci. Tech., 18: 96-101.

Diez, V.A. and A. Alvarez, 2001. Compositional and nutritional studies on two wild edible mushrooms from northwest Spain. Food Chem., 75: 417-422.

Eke-Ejiofor, J. and D. Kiin-Kabari, 2010. Chemical, pasting, functional and sensory properties of sweet and Irish potato chips. Nigeria Food Journal, 2: 47-48.

Eke-Ejiofor, J., 2013. Proximate and sensory properties of African breadfruit and sweet potato-wheat composite flour in cakes and biscuits. Inter. J. of Nutrition and Food Sciences, 5: 232-236.

Elmastas, M., O. Isildak, I. Turkekul and N. Temur, 2007. Determination of antioxidant activity and antioxidant compounds in wild edible mushrooms. J. Food Comp. Anal., 20: 337-345.

FAO/WHO, 1989. Protein quality evaluation. Report of the joint FAO/WHO expert consultation. Food and Nutrition Paper No. 51. Food and Agriculture Organizations and the World Health Organization, Rome, Italy.

Fayemi, P.O., 1999. Nigerian vegetables. Heinemann educational books (Nig.) Plc., pp: 94-95.

Gandhi, A., N. Kotwaliwale, J. Kawalkar, D. Srivastava, V. Parihar and N. Raghu, 2001. Effect of incorporation of defatted soy flour on the quality of sweet biscuits. J. Food Sci. Technol., 38: 502-503.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Microbiol., 144: 111-117. Procedures for Agricultural Research, 2nd ed. John 36. Heenan, S.P., J.P. Dufour, N. Hamid, W. Harvey and Wiley, New York, USA.

Grabowski, J.A., V.D. Truong and C.R. Daubert, 2008. Nutritional and rheological characterization of spray dried sweet potato powder. LWT., 41: 206-216.

Guang, Y.Q. and T. Wu, 2006. Determination of pharmacologically active ingredients in sweet potato (*Ipomoea batatas* L.) by capillary electrophoresis with electrochemical detection. J. Agri. Food Chem., 54: 24-28.

Gustafson, J.G., G.G. Yousef, M.A. Grusak and M.A. Lila, 2012. Effect of postharvest handling practices on phytochemical concentrations and bioactive potential in wild blueberry fruit. Journal of Berry Res., 2: 215-227.

Hegazy, A.I. and M.I. Ibrahium, 2009. Protein quality evaluation of wheat biscuit supplemented by fenugreek seed flour. World J. of Dairy and Food Sciences, 2: 129-135.

Hill, I.D., M.H. Dirks, G.S. Liptak, R.B. Colletti, A. Fasano and S. Guandalini, 2005. Guideline for the diagnosis and treatment of coeliac disease in children: recommendations of the North American Society for pediatric gastroenterology, hepatology and nutrition. J. Pediatric Gastroenterology and Nutrition, 40: 1-19.

Hooda, S. and S. Jood, 2005. Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chem., 90: 427-435.

Ihekoronye, A.I and P.O. Ngoddy, 1985. Integrated food science and Technology for the tropics. Macmillan Education Ltd., ISBN 0-333-38883-6.

Ishiguro, K., J. Toyama, S. Islam, M. Yoshimoto, T. Kumagai, Y. Kai and O. Yamakawa, 2004. "Suioh, A new sweet potato cultivar for utilization in vegetable greens," Acta Hortic., 637: 339-345.

Ishikawa, N.K., M.C. Kasuya and M.C. Vanetti, 2001. Antibacterial activity of *Lentinula edodes* grown in liquid medium. Br. J. Microbiology, 32: 206-210.

Israilides, C. and A. Philippoussis, 2003. Biotechnologies of recycling agro-industrial wastes for the production of commercially important fungal polysaccharides and mushrooms. Biotechnol. Genet. Eng. Rev., 20: 247-259.

Jauharah, M.Z., W.I. Rosli and S.D. Robert, 2014. Physicochemical and sensorial evaluation of biscuit and muffin incorporated with young corn powder. Sains Malaysiana, 43: 45-52.

Khaliduzzaman, M., U.D. Shams and M.N. Islam, 2010. Studies on the preparation of chapatti and biscuit supplemented with potato flour. J. Bangladesh Agril. Univ., 1: 153-160.

Kobori, M., M. Y.oshida, M. Ohnishi and H. Shinmoto, 2007. Ergosterol peroxide from an edible mushroom suppresses inflammatory responses in RAW264.7 macrophages and growth of HT29 colon adenocarcinoma cells. Br. J. Pharmacol., 150: 209-219.

Lillian B., B. Paula, M. Daniela, C. Susana, O. Beatriz and C. Isabel, 2007. Fatty acid, sugar compositions and nutritional value of five wild edible mushrooms from Northeast Portugal. Food Chemistry, 105: 140-145.

Lindequist, U., T.H. Niedermeyer and W.D. Julich, 2005. The pharmacological potential of mushrooms. Evidence-Based Complementary and Alternative Medicine (ECAM), 2: 285-299.

Maga, J.A., 1981. Mushroom flavour. Journal of Agriculture and Food Chemistry, 29: 1-4.

Manzi, P., L. Gambelli, S. Marconi, V. Vivanti and L. Pizzoferrato, 1999. Nutrients in edible mushrooms: An interspecies comparative study. Food Chemistry, 65: 477-482.

Mattila, P., K. Suonpaa and V. Piironen, 2000. Functional properties of edible mushrooms. Nutrition, 16: 694-696.

Mau, J.L., C.N. Chang, S.J. Huang and C.C. Chen, 2004. Antioxidant properties of methanolics extracts from *Grifola frondosa*, *Morchella esculenta* and *Termitomyces albuminosus mycelia*. Food Chemistry, 87: 111-118.

Misra, A. and K. Kulshrestha, 2003. Potato flour incorporation in biscuit manufacture, Plant Foods Hum. Nutr., 58: 1-9.

Nazni, P. and S. Pradeepa, 2010. Organoleptic Science Publishers Ltd., London. evaluation of biscuits prepared from potato flour, 10. AACC, 1995. Approved Methods of the American Beverage and Food World, pp. 31-34.

Nazni, P., S. Andal and S. Pradeepa, 2009. Comparative study on supplementation of potato flour biscuits on the nutritional and cognitive profile of the selected children. Iran J. Padiatr., 19: 285-292.

Padda, S. and D.H. Picha, 2008. Quantification of phenolic acids and antioxidant activity in sweetpotato genotypes. Scientia Horticulturae, 119: 17-20.

Padmaja, G., 2009. Uses and nutritional data of sweetpotato, in Loebenstein, G. and Thottappilly, G. (Eds.), The Sweetpotato. Springer, Belgium, Germany, pp: 189-234.

Paeaekkoenen, K. and R. Kurbela, 1987. Effect of drying method on the water sorption of blanched Northern milk cap mushrooms (*Lactarius trivialis*) at different temperatures. Lebens. Wiss. Technol., 20: 158-161.

Petrovska, B., 2001. An evaluation of the quality of some macedonian edible Boletaceae mushrooms. Macedonian pharmaceutical bulletin, 47: 21-26.

Purcell, A.E., W.L. Later and M.I. Lee, 1980. Analysis of the volatile constituents of baked, "Jewel" sweet potato. J. Agric. Food Chem., 28: 939-941.

Rbara, R., B. Paula, M. Branca, M. Msilva, B. Paula, M. Rosa and V. Patricia, 2008. Comparative study on free amino acid composition of wild edibl mushroom species. J. Agric. Food Chem., 56: 10973-79.

Reguła, J. and M. Siwulski, 2007. Dried shitake (*Lentinulla edodes*) and oyster (*Pleurotus ostreatus*) mushrooms as a good source of nutrient. Acta. Sci. Pol. Technol. Aliment, 6: 135-142.

Ribeiro, B., P. Valentao, B. Paula, R.M. Seabra and P.B. Andrade, 2007. Phenolic compounds, organic acids profiles and antioxidative properties of beef steak fungus (*Fistulina hepatica*). Food Chem. Toxicol., 45: 1805-1813.

Sharma, H. and G. Chauhan, 2002. Effects of stabilized rice bran-fenugreek blends on the quality of breads and cookies. J. Food Sci. Technol., 39: 225-233.

Singh, J., th N. Singh, T.R. Sharmab and S.K. Saxena, 15A, 44-13, 08-01, 30-10 and 32-10. The Association: 2003. Physicochemical, rheological and cookie St. Paul, MN, USA.

Singh, S., C.S. Riar and D.C. Saxena, 2008. Effect of incorporating sweet potato flour to wheat flour on the quality characteristics of cookies. African Journal of Food Science, 2: 65-72.

Sudha, M., R. Vetrimani and K. Leelavathi, 2007. Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chem., 100: 1365-70.

Suzuki, S. and S. Oshima, 1996. Influence of shitake *(Lentinus ododes)* on human service drollestrol. Mushroom Science, 9: 463-467.

Teng, F., T. Bito, S. Takenaka, Y. Yabuta and F. Watanabe, 2014. Vitamin B_{12} a biologically inactive coronoid compound occurs in cultured and dried lions mushroom fruiting bodies. J. Agric. Food Chem., 62: 1726-32.

Tilman, J.C., M.O. Colm, M.C. Denise, D. Anja and K.A. Elke, 2003. Influence of gluten free flour mixes and fat powder on the quality of gluten free biscuits. Eur. Food Res. Technol., 216: 369-376.

Turkoglu, A., M.E. Duru, N. Mercan, I. Kivrak and K. Gezer, 2007. Antioxidant and Antimicrobial activities of *Laetiporus sulphureus* (Bull) Murrill. Food Chem., 101: 267-273.

Varughese, G., W.H. Pfeiffer and R.J. Pena, 1996. A successful alternative crop. I. Cereal Foods World, 41: 474-482.

Vasantharuba S., P. Banumathi, M.R. Premalatha, P. Sundaram and T. Arumugam, 2012. Studies on the Preparation of Biscuits Incorporated with Potato Flour. World Journal of Dairy and Food Sciences, 7: 79-84.

Walter, W.M., W.W. Collius and A.E. Purcell, 1984. Sweet potato protein: A review. J. Agric. Food Chem., 32: 695-699.

Wang, H., J. Gao and T. Ng, 2000. Anew lectin with highly potent antihepatoma and antisarcoma activities from the oyster mushroom *Pleurotus ostreatus.* Biochem. Biophys. Res. Com., 275: 810-816.

Wan-Rosli, W.I., A.R. Nurhanan and M.S. Aishah, 2012. Effect of partial replacement of wheat flour with oyster mushroom (*Pleurotus sajor-caju*) powder on nutritional composition and sensory of biscuit. Sains Malaysiana, 41: 1565-70.

Wasser, S.P. and A.L. Weis, 1999. Medicinal properties of substances occurring in Higher basidiomycetes mushrooms: current perspectives (review). Int. J. Med. Mushrooms, 1: 31-62.

Yadav, A.R., M. Guha, R.N. Tharananthan and R.M. Ramteke, 2006. Influence of drying conditions on functional properties of potato flour. Eur. Food Res. Technol., 223: 553-560.

Yaovadee, C., H. Duangchan, M. Wanpen and Y. Sompoch, 2010. Quality and quantity of protein in certain kinds of edible mushroom in Thailand. Kasetsart J. Nat. Sci., 44: 664-670.

Yeoh, H. and V. Truong, 1996. Amino acid composition and nitrogen-to-protein conversion factors for sweet potato. Trop. Sci., 36: 243-246.